2002–03 Space Science Enterprise Overview

Scientists in NASA's Space Science Enterprise seek to answer fundamental questions about the origin and evolution of life and celestial objects (planets, planetary systems, stars, galaxies, etc.) in the universe. These questions are central to both the new NASA vision for the future: "To improve life here, To extend life to there, To find life beyond," and the new NASA mission: "To understand and protect our home planet, To explore the Universe and search for life, To inspire the next generation of explorers..., as only NASA can," as articulated by NASA Administrator Sean O'Keefe.

Ames is recognized as a world leader in Astrobiology, the study of life in the universe and the chemical and physical forces and adaptations that influence life's origin, evolution, and destiny. In pursuing our primary mission in Astrobiology, Ames performs pioneering basic research and technology development to further fundamental knowledge about the origin, evolution, and distribution of life within the context of cosmic processes. For example, research and technology development are currently conducted to:

- *Study the mechanisms of the origin, evolution, and distribution of life in the universe;*
- *Determine the abundance and distribution of the biogenic compounds that are conducive to the origin of life;*
- *Identify locations on bodies within our solar system where conditions conducive to life exist or have existed;*
- *Explore the other bodies (planets, comets, asteroids) of our solar system;*
- *Locate planets and planet-forming regions around other stars;*
- *Study extra-solar matter such as interstellar gas and dust*.

Research at ARC implements NASA and Space Science Enterprise goals through four elements dealing with Astrophysics, Planetary Systems, Exobiology, and Astrobiology Technology. Since a unifying theme for these elements is the origin and evolution of stars, planets, and life, the total research effort is a major thrust of the Space Science Enterprise's Astrobiology program. Astrophysics research addresses Enterprise goals and objectives that deal with understanding how the structure in the Universe emerged, the dynamical evolution of galaxies and stars, and the exchange of matter and energy among stars and the interstellar medium. Planetary Systems research addresses Enterprise goals and objectives that deal with understanding star formation, the evolution and distribution of volatile and organic material, the origin and distribution of planetary systems, rings, and primitive bodies, and planetary atmosphere evolution. Exobiology research addresses Enterprise goals and objectives that deal with understanding the origin, evolution, and distribution of life by conducting research on the cosmic history of biogenic compounds, prebiotic evolution, the early evolution of life, computational astrobiology, and extreme environments in which living organisms can exist. Astrobiology Technology supports fundamental research and the development of advanced technologies in astrobiology as they relate to the exploration of space and understanding of life in the universe.

This report highlights accomplishments in the four key research thrusts at Ames that support the goals and objectives of the Enterprise: Astrophysics, Planetary Systems, Exobiology, and Astrobiology Technology.

ASTROPHYSICS

As NASA's lead in airborne astronomy, scientists at Ames pioneered the field of astrophysics. Study topics range from star forming regions and processes to interstellar photochemistry to protoplanetary disks. Understanding cosmic processes—the evolution of the universe itself— is a vital part of the Origins initiative.

Ames' astronomers and astrophysicists utilize a wide variety of methods. Ground-based telescopes such as the Keck and Mount Lemmon Observatories, are regularly employed for observations of celestial objects and processes. Development continues on the Stratospheric Observatory for Infrared Astronomy (SOFIA), an infrared telescope to be carried aboard a Boeing 747 aircraft specially modified for the task. Space-based observations are also made through instruments such as the Hubble Space Telescope (HST) and other observatories and missions. Computer modeling and laboratory analogs of chemical processes enhance the observational astronomy performed.

Highlighted in this section of the report are a wide variety of accomplishments in astrophysics including:

- *Successful modeling of the observed color in icy planetary satellites using mixtures of ice and complex organic materials which sheds light on prebiotic organic chemical processes;*

- *Development of a cryogenic multiplexer for far infrared photoconductor detectors operating at moderate backgrounds for instruments for a new generation of large telescopes such as SOFIA;*

- *Contributions to the concept that Deuterium enrichment in meteorites indicates that organic species made in the ISM can survive the transition from a dense cloud through infall onto a planetary surface.*

PLANETARY SYSTEMS

Scientists in the Space Science Enterprise are interested in how and where in the universe planets form, and the geophysical, geochemical, and atmospheric processes that have occurred over the lifetime of a planet. Further, understanding the dynamics between planetary processes and the origin and evolution of life will help us understand the distribution of life in the universe.

Highlighted in this section of the report are a wide variety of accomplishments in planetary systems including:

- *New models which take into account the scatter of light from grainy surfaces shed new light on the composition of Saturn's rings;*

- *Theoretical models of particle —gas interactions in turbulent nebula flows helping to explain the abundance of Calcium-Aluminum-rich Inclusions (CAIs) in meteorites;*

- *The PASCAL Mars Scout Mission global network of long-lived landers to characterize the meteorology and climate of Mars;*

- *Theoretical research on star and planet formation conducted via consortium by the Center for Star Formation;*

- *The lessons of brown dwarf detection that can be applied to our search for extra solar planets;*

- *Novel techniques to detect and characterize large data sets from astronomical surveys identifying galaxy clusters without preset assumptions and conditions;*

- *Atacama desert in Chile, the best known Mars analog for scientist to perform soil chemistry and mineralogy studies in preparation for Mars exploration opportunities.*

EXOBIOLOGY

Ames' Exobiology Program is a key element of NASA's Astrobiology Initiative and Ames serves as NASA's lead center in exobiology. Research in exobiology at Ames ranges from studying the mechanisms of the origin of living systems, to the processes governing the evolution of life, and to the distribution of life on other planets. When coupled with Ames' pioneering research on the dynamics of galaxies, molecular gases and clouds, planetary systems, and the solar system, our study of life is facilitated by understanding the cosmic environment within which life originates and evolves.

Molecules of exobiological significance are ubiquitous in the universe. It is important to understand the sources and interactions of these building blocks and how living systems emerge from prebiotic molecular chaos.

Highlighted in this section of the report are a wide variety of accomplishments in exobiology including:

- *Biomarker analysis of ancient sediments associated with Cyanobacterial ecosystems might allow recognition of similar source organisms and environmental conditions on other worlds;*

- *Penning Ionization electron spectroscopy a new analytical technique that requires minimal flight resources while providing analyses of volatile complex chemical mixtures of atmospheres and surfaces of planetary bodies;*

- *The formation of protocells—membrane enclosed structures endowed with ubiquitous cellular functions—was a central step in evolution from inanimate to animate matter.*

ASTROBIOLOGY TECHNOLOGY

Ames' Astrobiology Technology Program supports fundamental research and the development of advanced technologies in astrobiology as they relate to the exploration of space and understanding life in the universe.

Highlighted in this section of the report are a wide variety of accomplishments in astrobiology including:

- *Atmospheric resources for exploration of Mars – has many of the ingredients needed to support human exploration missions;*

- *Nanotechnology – Technology on the scale of molecules, which holds the promise of creating devices smaller;*

- *The Vapor Phase Catalytic Ammonia Removal system technology represents the next generation in space flight water recovery system;*

The Division is organizationally divided into four Branches named according to the focus areas of the research conducted by the scientists in those Branches: Astrophysics, Planetary Systems, Exobiology, and Astrobiology Technology (see Figure 1).

In 2003, the Division employed 79 civil service personnel, approximately 50 of whom are Ph.D. scientists. This core permanent staff is augmented with approximately 125 non-civil servant scientists and technical support personnel who are resident in Division facilities through mechanisms such as grants, cooperative agreements, support contracts, fellowships, visiting scientist positions, and student internships.

It is common for visiting scientists to spend their summer research or sabbatical time in the Division's laboratories and facilities. Extensive ties are maintained with the academic community through collaborative research programs and also through the development of science curricular materials. The Space Science Division is dedicated to fostering greater interest in careers in the sciences and provides unique opportunities for training the next generation of scientists. Students at all levels—high school, undergraduate, graduate, and post-doctoral—represent a significant component of the Division's on-site research work force. In 2000, approximately 20 National Research Council Postdoctoral Fellows and 10 undergraduate students were resident in the Division. Division personnel also mentored students in the Astrobiology Academy, a competitive program for college undergraduates to participate in hands-on research projects here at Ames Research Center.

In the following section of the Annual Report, the research programs of each Branch are summarized. Within each area, several examples of research topics have been selected (from a total of approximately 130 tasks) for more detailed description. Following that section is a list of publications authorized by Division personnel with 2002 and 2003 publication dates. Finally, if a particular project is of interest, the personnel roster that begins on page 73 may be used to contact individual scientists.

Mark Fonda

Acting Chief, Space Science Division

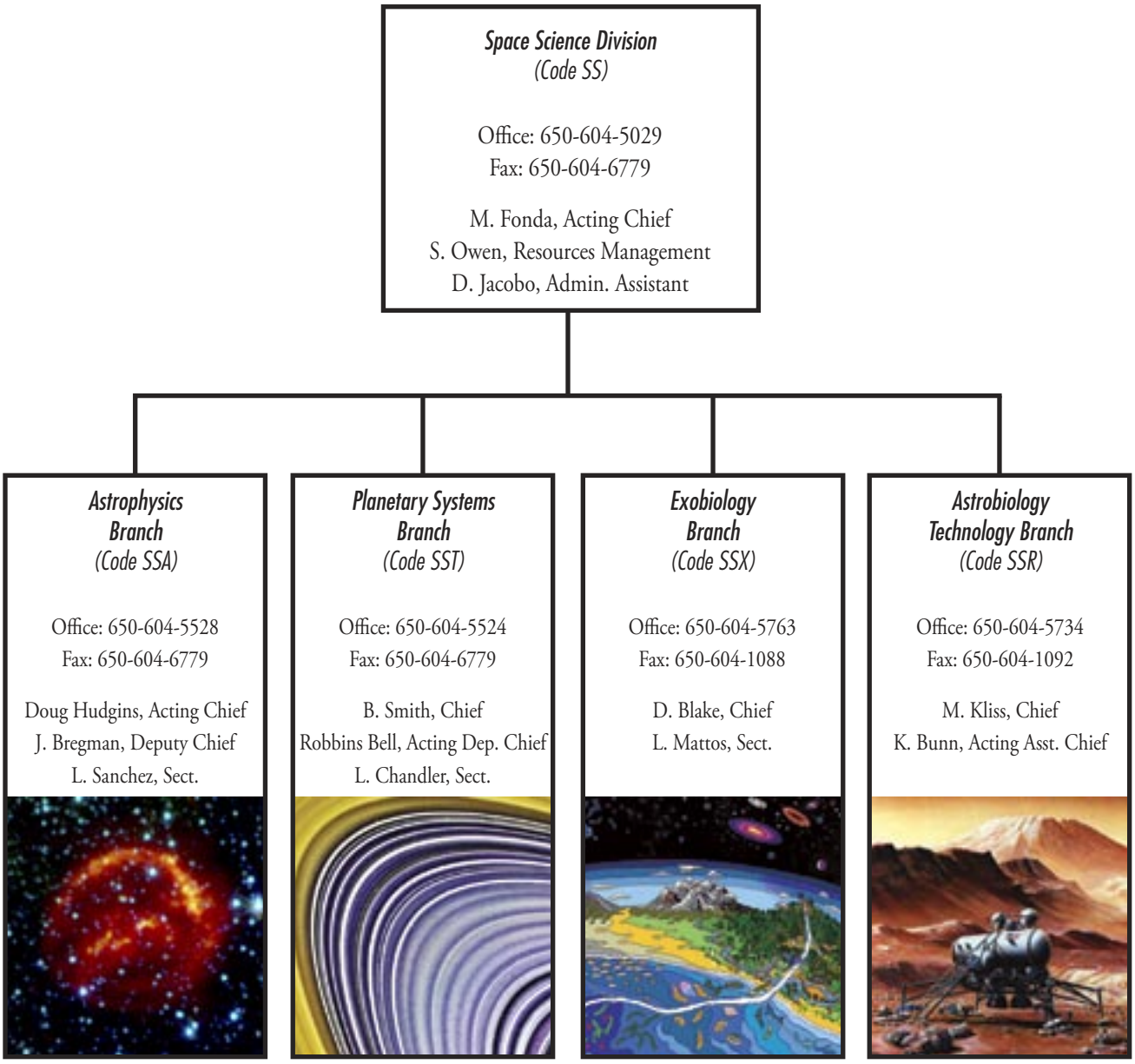
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Figure 1.